PB-217 772

WATER RESOURCES STUDY, MARKED TREE SIPHON, ST. FRANCIS RIVER BASIN, ARKANSAS. STUDY OF POTENTIAL NEED FOR AND VALUE OF STREAMFLOW REGULATIONS FOR CONTROL OF WATER QUALITY BELOW THE MARKED TREE SIPHON

Public Health Service
Dallas, Texas

February 1963

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WATER RESOURCES STUDY

MARKED TREE SIPHON

ST. FRANCIS RIVER BASIN

ARKANSAS

Study of Potential Need for and Value of Streamflow Regulation for Control of Water Quality Below the Marked Tree Siphon

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

In Cooperation with the

DEPARTMENT OF THE ARMY
U.S. Army Engineer District--Memphis, Tennessee

FEBRUARY 1963

30

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ST. FRANCIS RIVER BASIN

ARKANSAS

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I. INTRODUCTION

Authority

The Corps of Engineers, Memphis District, in a letter dated June 22, 1962, requested that the Public Health Service " . . . determine the need for and the value of storage, in St. Francis Lake, for regulation of stream flow for the purpose of water quality control in the St. Francis River."

Purpose and Scope

This report presents information and data pertaining to streamflow requirements for water quality control purposes to the year 2020 in the St. Francis River below the Marked Tree Siphon.

Estimates are made of the average annual benefits for a period of 50 years that will accrue from works providing necessary flow regulation to meet water quality objectives.

Acknowledgments

Acknowledgment is gratefully made for the cooperation and assistance of the following:

Arkansas State Agencies:

State Board of Health
State Water Pollution Control Commission
State Department of Labor

Federal Agencies:

U.S. Department of the Army
U.S. Department of Agriculture
U.S. Department of Commerce
U.S. Department of the Interior
U.S. Department of Labor

Local officials in the Marked Tree area.

II. SUMMARY AND CONCLUSIONS

Summary

1. The proposed Project is concerned with control of erosion in the area of the diversion works, on the St. Francis River, in the vicinity of Marked Tree, Arkansas.

2. The study area, located in northeastern Arkansas, comprises Poinsett and Cross Counties and that portion of Crittenden County expected to affect water quality in the Project area (St. Francis River below the Marked Tree Siphon) by direct use or waste releases.

3. Major municipalities in the study area include Trumann, Lepanto, Marked Tree, Earle, and Parkin.

4. No reservoirs are currently existing, or under construction, in the study area. St. Francis Lake is sunken lands within the St. Francis River floodway, approximately 3½ miles north of Marked Tree.

5. The quality of water in the St. Francis River below the Marked Tree Siphon is of very good chemical quality--within limits suggested by the Public Health Service Drinking Water Standards, 1961.

Conclusions

1. The study area's population is expected to increase from 78,000 in 1960 to 100,000 by the year 2020.

2. Projected municipal and industrial water needs in the year 2020 total 11 mgd.

3. Water supply needs in the study area can be met from existing sources of supply.

4. The expected monthly distribution of mean annual low flows expected to recur once in 20 years is more than adequate to assimilate treated future waste discharges to the St. Francis River below the Marked Tree Siphon, in absence of the project.

Waste discharges resulting from municipal, industrial, and agricultural growth are not expected to be of the magnitude or type to deteriorate significantly stream quality.

Based on expectations of the foreseeable future, there is no need for, or benefit from, regulation of streamflow for the purpose of water quality control.

III. DESCRIPTION OF PROJECT

Location and Operation

As shown on Figure 1, the main flow of the St. Francis River is carried through a floodway canal from a point just upstream from Marked Tree for a distance of about 20 miles. Marked Tree, Arkansas, is located on the east bank of the St. Francis River at approximately river mile 75.

A siphon immediately upstream from Marked Tree (in the vicinity of St. Francis Lake*) is used to pass water over the levee to maintain flow in the original river channel. Operation of the siphon has been a function of the water level in the floodway canal. Erosion in the area of the diversion works (siphon) has resulted in reducing flows in the original St. Francis River channel. The proposed Project will control the erosion, thus restoring higher flows through the siphon to the original channel.

Streamflow

Most of the 8,400 square-mile drainage basin of the St. Francis River is located above Marked Tree. Combined discharge (floodway and river) at Marked Tree has averaged 5,930 cfs since 1935 with the river flow accounting for 1,670 cfs. 1/ Maximum recorded discharge in the river is 7,120 cfs. Minimum recorded discharge is 63 cfs.

The U.S. Geological Survey maintains a gaging station on the St. Francis River at Marked Tree and one three miles north of Marked Tree in the floodway which bypasses the town. Discharge records from 1935-1961 are available for both stations. Hydrographs of actual flow in the river at Marked Tree and estimated flow without the siphon were supplied by the Corps of Engineers for a 10-year period ending in 1961. 2/ Figure 2, a discharge frequency curve, was constructed utilizing these data.

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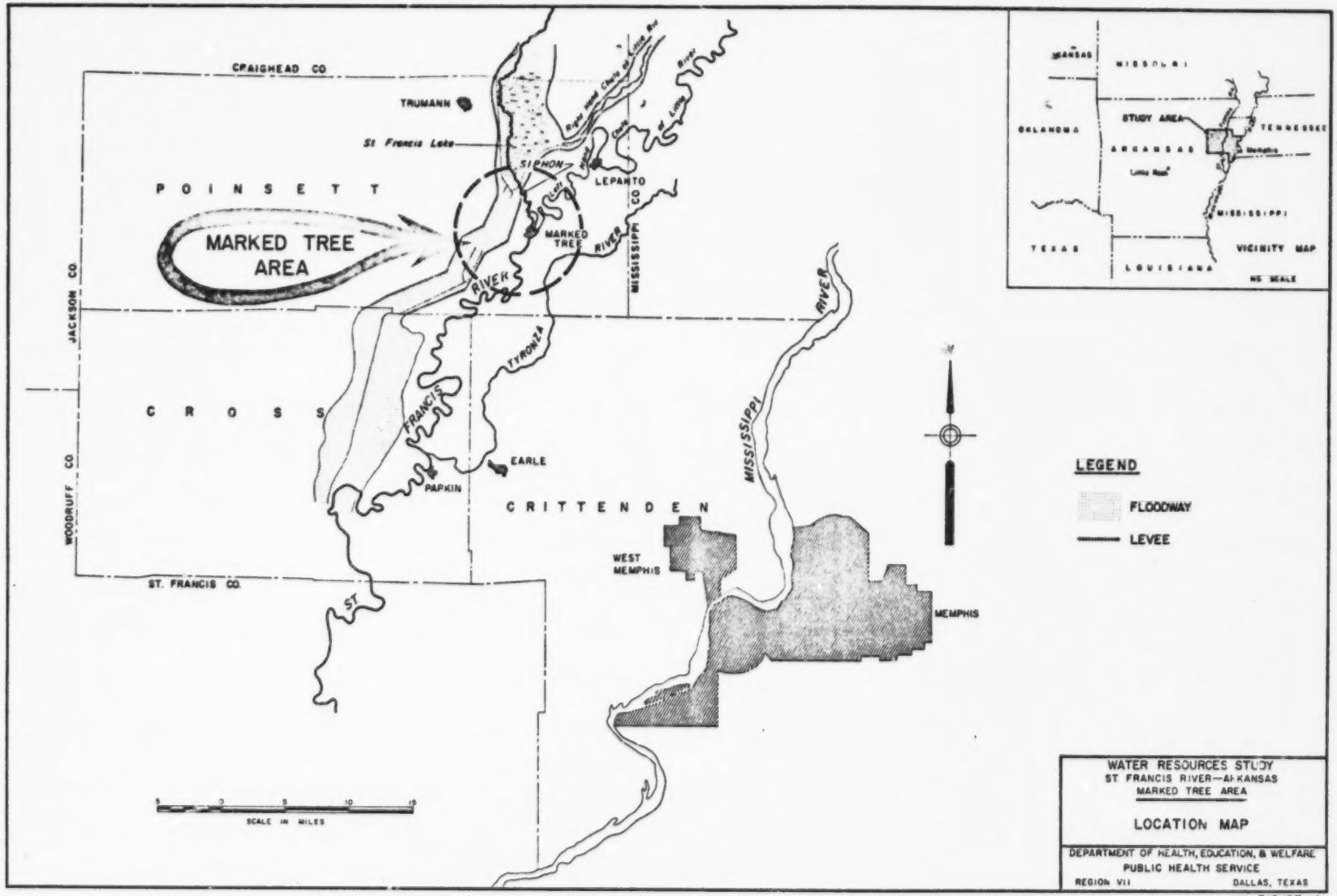
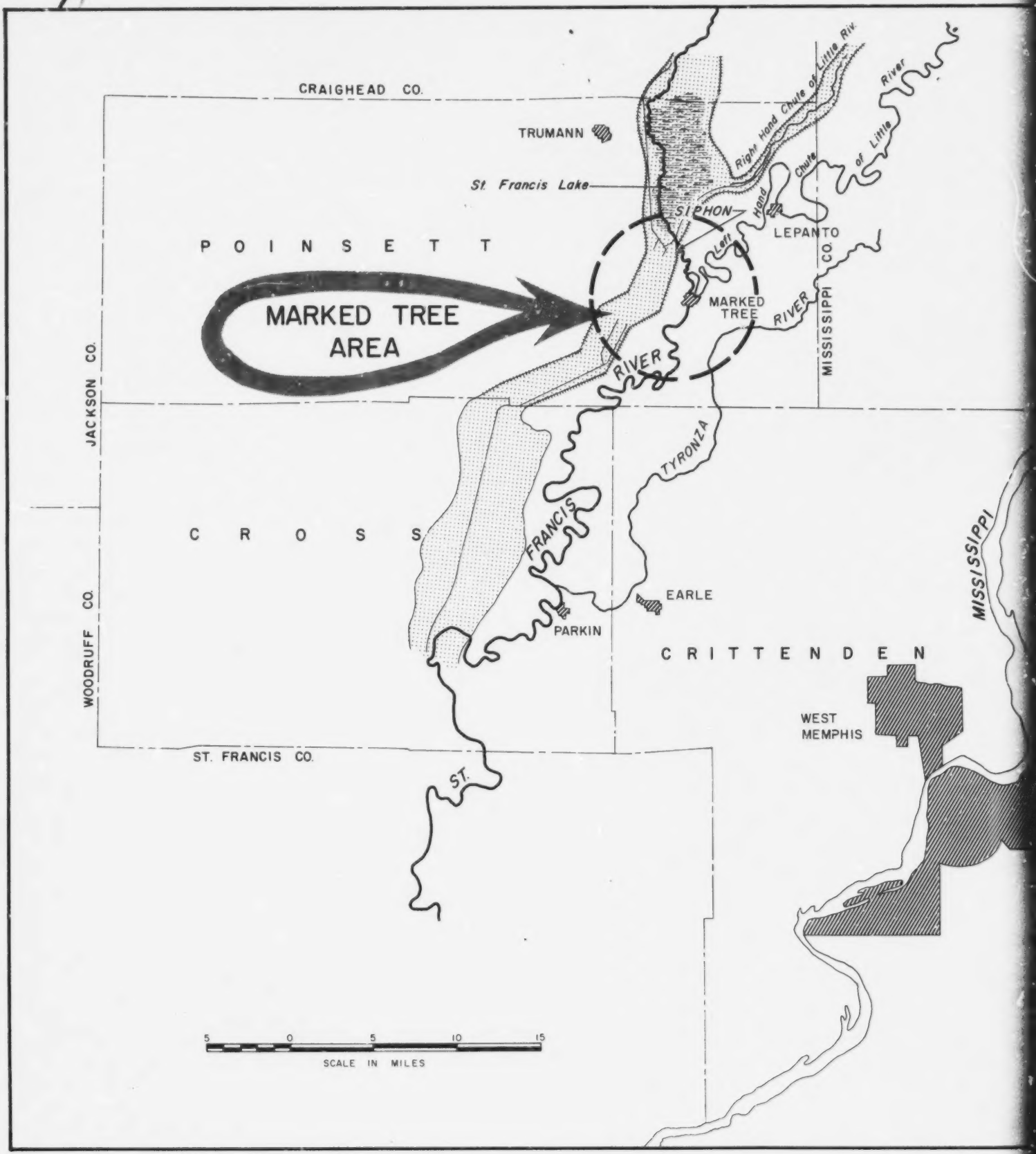
*The lake is generally no more than a marsh area.

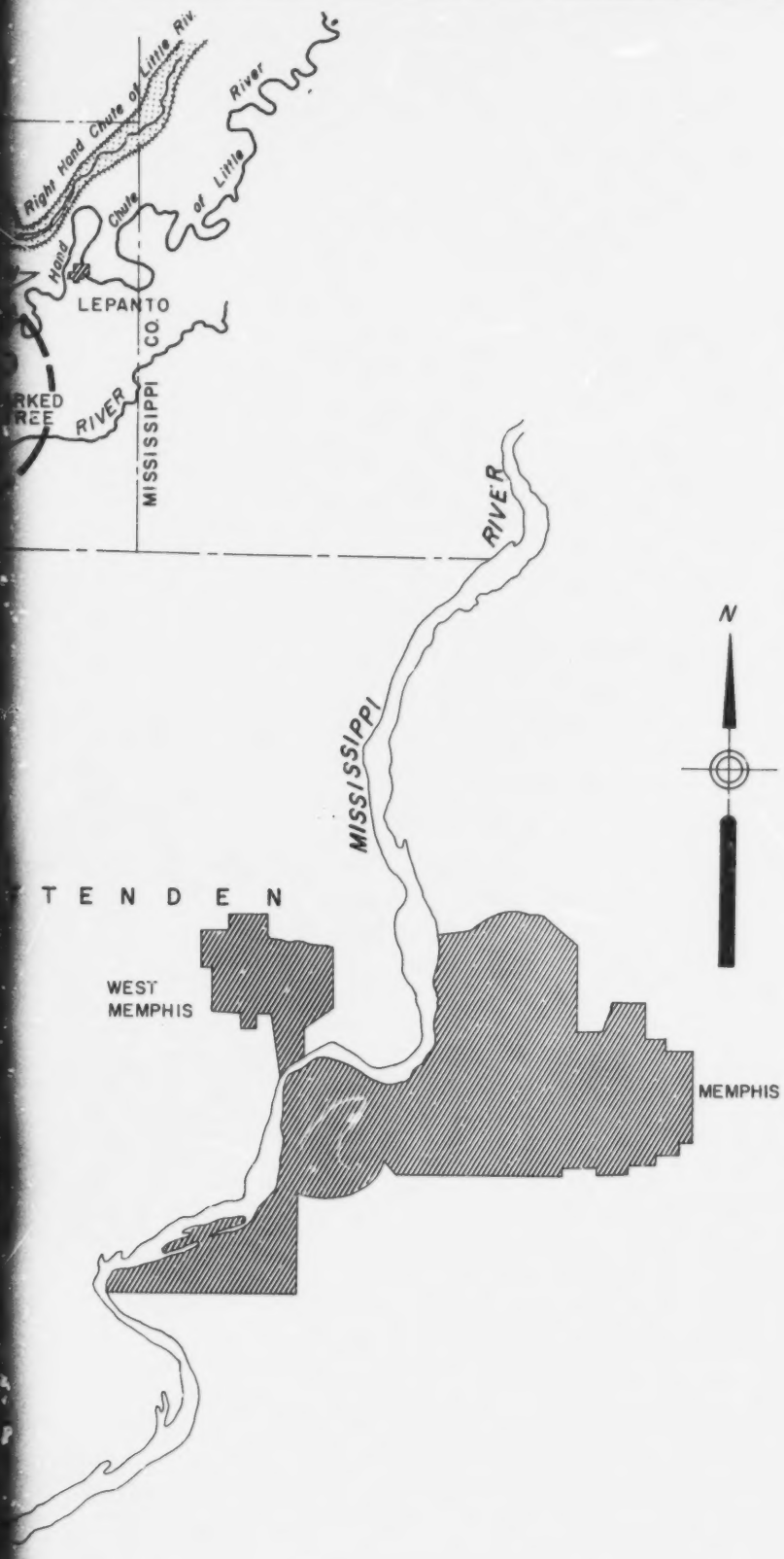


III - 2 FIGURE 1

A


CRAIGHEAD CO.
TRUMANN
St. Francis Lake
Right Hand Chute of Little Riv.
Left Hand Chute of Little River
SIPHON
LEPANTO
POINSETT
MARKED TREE AREA
MARKED TREE
MISSISSIPPI CO.
RIVER
JACKSON CO.
TYRONZA
CROSS
FRANCIS
EARLE
PARKIN
MISSISSIPPI
CRITTENDEN
WOODRUFF CO.
WEST MEMPHIS
ST. FRANCIS CO.
ST.
5 0 5 10 15
SCALE IN MILES

B

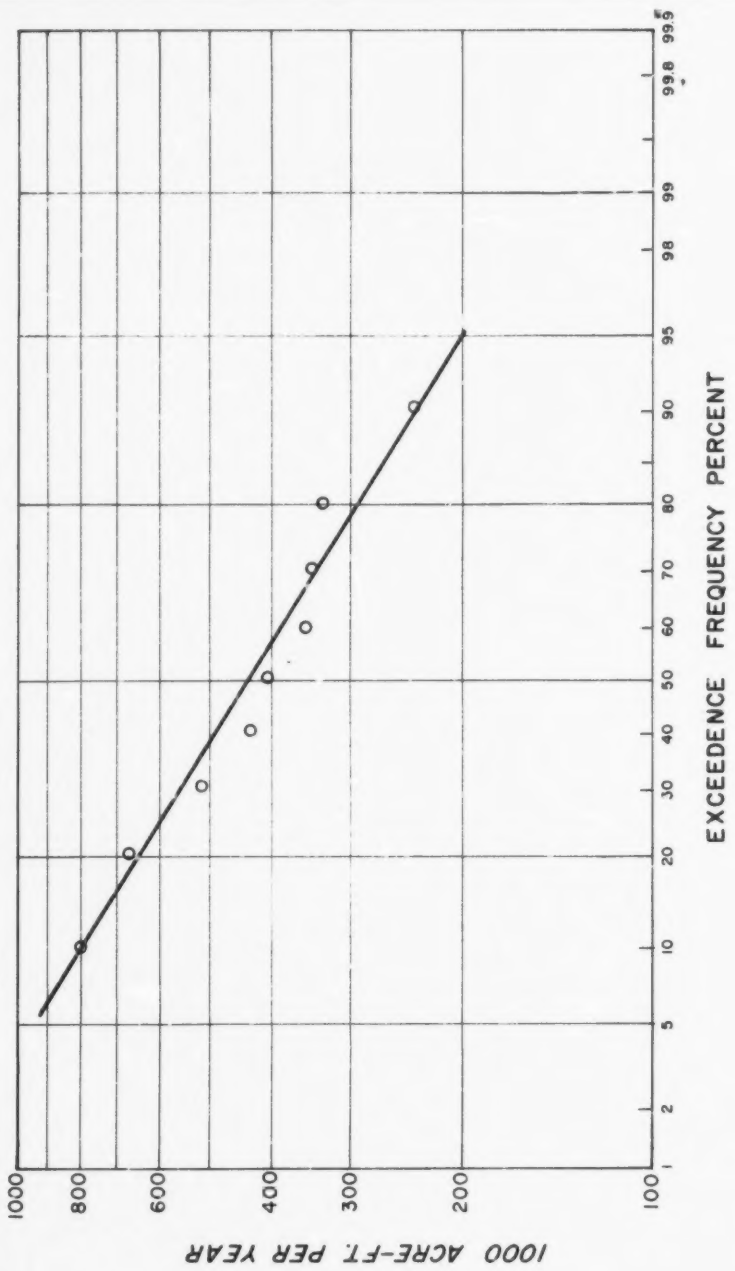


WATER RESOURCES STUDY
ST. FRANCIS RIVER—ARKANSAS
MARKED TREE AREA

LOCATION MAP

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 1



WATER RESOURCES STUDY

ST. FRANCIS RIVER – ARKANSAS

MARKED TREE AREA

ANNUAL DISCHARGE FREQUENCY

FLOW IN RIVER AT MARKED TREE
WITHOUT SIPHON

DEPARTMENT OF HEALTH, EDUCATION & WELFARE

PUBLIC HEALTH SERVICE

REGION VII DALLAS, TEXAS

FIGURE 2

IV. DESCRIPTION OF STUDY AREA

Location and Boundaries

The study area is located in northeastern Arkansas along approximately 40 miles of the St. Francis River, a tributary to the Mississippi.

As shown on Figure 1, the study area consists of two complete counties, Poinsett and Cross, together with most of Crittenden County. Poinsett and Cross Counties directly influence St. Francis River's water quality.

Only that portion of Crittenden County expected to affect water quality by direct use or waste releases is considered. This results in exclusion of the West Memphis area's influence on water quality although its effect on the economy of the area is considered.

General Features

The terrain of the study area is level to gently rolling, characteristic of the Mississippi Alluvial Plain (or Delta) in which it lies. Elevations in the area range from 100 to 300 feet above sea level.

The area enjoys a subhumid climate with mean monthly temperatures ranging from 37°-80° (F) and a mean annual rainfall ranging from 45-50 inches.

V. ECONOMICS AND POPULATION

Agriculture

Since 1920, agriculture has provided the chief source of income in the study area. In recent years, however, there has been considerable fluctuation in employment and number of farms. Agricultural employment in the three-county area declined 50 percent between 1950 and 1960 (see Table V-1). Since 1944, the number of farms has declined 64 percent (see Table V-2).

Table V-1 3/

Employment by Industries for the Study Area*
1950 and 1960

Year	Agriculture	Forestry and Fishery	Mining	Construction	Manufacturing
1950	20,295	148	39	1,101	1,766
1960	10,382	33	4	1,240	2,981

*West Memphis excluded.

Table V-2 4/

Summary of Agricultural Statistics for the Study Area

Year	No. of Farms	Acres of Cropland Harvested	Value of Farm Products Sold*	
			Crops	Livestock
1944	14,762	557,836	33,495	1,899
1949	13,612	652,182	50,316	1,508
1954	10,370	702,190	66,818	1,508
1959	5,382	770,091	76,663	2,098

*Values in 1,000's of constant 1960 dollars.

The acres of cropland harvested, however, increased by 14 percent from 1944 to 1959 (Table V-2) indicating a trend toward larger farms. A substantial increase is also shown for the period in the value of crops and livestock sold. Value of crop production increased by 130 percent, while the value of livestock production increased by about 10 percent (Table V-2). A trend toward more

productivity is also indicated. Much of the seasonal crop production in the study area utilizes migratory workers. 5/ The 10-county Upper Mississippi River Delta and St. Francis-Cache River cotton area, in which the study area lies, employed 22,000 migratory* workers during a peak employment period (month of September) in 1960. This amounted to 38 percent of all seasonal crop workers employed during that period.

Should the trend toward fewer and larger farms and use of outside help continue, growth in local agricultural employment, presently the chief source of income in the study area, may be restricted.

The 10-county area mentioned above constitutes some of the most important farming land in the State. Over 35 percent of the State's cotton acreage lies within the region.

Other major crops produced in the area include rice, soybeans, strawberries, and mixed vegetables.

Forestry

Approximately 23 percent (290,000 acres) of the study area was designated as commercial forest land in 1959. Total cut for the year was 6.4 million $ft.^3$. Approximately 98 percent of the growing stock in 1959 (total - 143 million $ft.^3$) was hardwood, consisting of oak, gum, cypress, and oak hickory. 6/ This wood is used primarily for flooring, furniture, veneers, poles, and pilings.

Minerals

Sand and gravel account for most of the mineral extraction in the study area. The value of production has fluctuated in recent years, ranging from $197,000 in 1955 to a peak of $364,000 in 1958.** The production reported in 1960 was valued at $116,000. 7/

Manufacturing

Furniture and fixtures and textile and apparel accounted for 63 percent of the study area manufacturing employment in 1960. 3/ The bulk of production of these commodities was centered at three locations and operated by nationally marketing firms.

---

* These include workers from out of the State and foreign national contract workers (generally Mexican). 5/

**Figures shown are given in constant 1960 dollars.

Several other industries are active in the area, though on a smaller scale. Most significant among those remaining are primary wood-using plants and food and kindred firms. Primary wood-using plants in the area include sawmills, and handle and furniture stock mills.

The value added by manufacture for the study area increased from $3.9 million in 1947 to $10 million in 1954. 8/ (More recent data are incomplete.)

Population

The population of the three-county area, exclusive of the city of West Memphis*, has undergone significant fluctuation since 1920 and has experienced a declining trend since 1940. Beginning with 69,000 in 1920, the area grew to 103,000 by 1940. The decrease (23 percent) to 79,000 in 1960 has largely been due to changing agricultural trends (mentioned earlier), which have resulted in a sharp decline in rural population (37 percent). Growth of the furniture and textile manufacturing industries in the area has helped check the population decline to some extent. Since 1920, the municipal population has grown from 15,000 to 26,000 (73 percent increase). 3 9/

Future Economic and Population Growth

The study area is endowed with some natural resources for which an increase in demand is anticipated. These include--forest resources (hardwoods) and sand and gravel. Central location, with respect to national markets, and nearby access to raw materials (hardwood and cotton) should continue to encourage growth in furniture and apparel manufacturing in the study area.

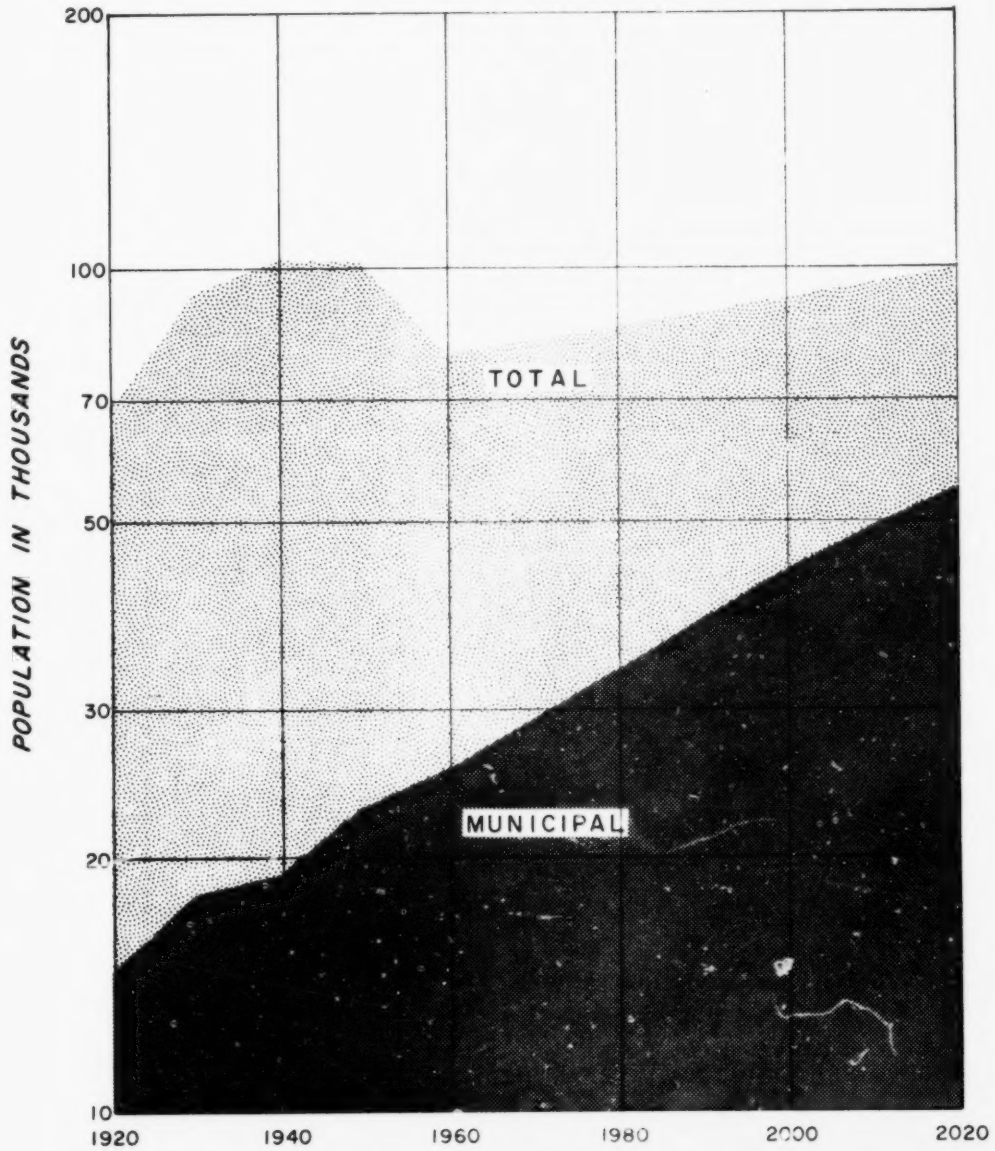
The study area is located in an important farming region. Agricultural production is expected to continue in an upward trend thereby stabilizing the decreasing trend in agricultural employment.

Trade and service industries are expected to keep pace with agricultural and manufacturing growth in the area. The growth of Memphis, Tennessee (a city of over 500,000 population--located within 40 miles of most of the study area) is expected to have significant influence on study area growth, particularly as a market for goods produced in the study area.

---

*Since the city of West Memphis (located in the lower portion of the study area) reflects the growth of Memphis, Tennessee, and not the study area in general, it is excluded in the economic analysis and is considered as an outside influence in making growth projections.

Indications are that the study area is favorably situated to participate in projected national growth. Recent downward population trends are expected to change as the rural population becomes more stable. With continued growth in municipal population, the study area is expected to attain a population of 100,000 by 2020 (see Figure 3).



WATER RESOURCES STUDY

ST FRANCIS RIVER – ARKANSAS
MARKED TREE AREA

POPULATION PROJECTIONS

POINSETT, CROSS & CRITTENDEN
COUNTIES – EXCLUDING WEST MEMPHIS

DEPARTMENT OF HEALTH, EDUCATION & WELFARE

PUBLIC HEALTH SERVICE

REGION VII DALLAS, TEXAS

V. 5

FIGURE 3

VI. WATER USE

Historic Municipal and Industrial

Combined water use for the principal municipalities in the study area presently average about 1 mgd as shown in Table VI-1.

Table VI-1

Municipal Water Use and Water Supply Data [10/]

Municipality	Present Avg. Demand (mgd)	Source	Yield (mgd)
Trumann	0.30	Several Wells	1.3 E*
Lepanto	0.10	3 wells	1.0 E
Marked Tree	0.15	3 wells	1.0 E
Earle	0.20	3 wells	1.3
Parkin	0.10	1 well	1.4
Total	0.85		6.0

* Estimate.

Since water supply systems in the area are small and do not keep records, historic municipal water use data are not available.

No significant water using industries are presently within the area.

Several light manufacturing industries are operating in the area; however, water used for these installations is largely for sanitary purposes and is estimated to be about equal to municipal uses.

Projected Needs for Municipal, Industrial, and Other Purposes

The anticipated water requirements of the study area to the year 2020 are projected in order to describe expected waste return flows.

Since no heavy industrial water use is forecast for the area, a single unit demand, including both municipal and light industrial use, was derived. The unit municipal and light industrial water use for the year 2020 is expected to be 200 gallons per capita day. Future municipal water needs for the area then, are the result of multiplying the estimated per capita use by the projected municipal population. On this basis, the projected municipal and industrial water requirement for the study area is estimated to be 11 million gallons per day in the year 2020.

Since water use for other purposes is not expected to contribute substantially to waste loadings in the St. Francis River, future water use projections are limited to those listed above.

Water Quality Control

Protection of the quality of Arkansas waters is primarily the responsibility of the Arkansas State Board of Health. Stream quality criteria and subsequent regulations governing waste discharges come from this agency. The use of water, however, generally results in the production of some liquid wastes which, even after a high degree of treatment, may degrade the quality of the receiving stream.

As treatment methods improve, the need for addition of water to maintain quality will diminish and may someday disappear. Until that time, however, it is essential that recognition be given to the need for flows which must prevail in the receiving streams if their water quality is to be maintained at acceptable levels.

Estimates of the water required to maintain satisfactory quality in the St. Francis are, therefore, a significant part of plans for regulation of streamflow in the study area.

Water quality determinations take into consideration the wastes which will result from economic development of an area and the effects of these wastes on the stream. The quality of water at any point in the stream is the result of mixing various qualities and quantities of waters which make up the total flow modified by forces such as reaeration and evaporation which tend to change its character.

Though the project would provide little, if any, improvement in the mineral quality of water, total dissolved solids are used as a measure of the mineral constituents in water.

Dissolved oxygen content is employed as a measure of organic pollutants in water.

In determining quality control requirements in the St. Francis River below the siphon, the following assumptions are used:

1. Sufficient treatment will be provided to remove 90 percent of the biochemical oxygen demand.

2. Uniform mixing of wastes and receiving waters will occur.

3. Quality control by flow regulation is required when the dissolved oxygen content of the mixed water in the stream is below 4.0 milligrams per liter (mg/l.) or the total dissolved solids exceed 500 mg/l.

A discharge frequency analysis of the St. Francis River at Marked Tree and Parkin, based on annual runoff without the siphon in operation, was made from discharge hydrographs furnished by the Corps of Engineers. This sequence of flow was then compared to a frequency analysis of total annual discharge at Marked Tree (river and floodway) made from 26 years of U.S. Geological Survey data. Periods of high and low flow for the restricted flow conditions and total flow conditions were comparable.

Calculations were then made to determine the hydrologic conditions (flows) that could be expected to recur in the river every 5, 10, and 20 years, respectively. Annual low flow distribution at 80, 90, and 95 percent exceedence frequencies are given for the river at Marked Tree in Table VI-2. 2 11/

These flows were then used to arrive at a projected water quality and subsequently the need for flow regulation for control of water quality in the St. Francis River.

Determination of projected water quality under the above flow conditions indicated that the St. Francis River below the Marked Tree Siphon will not be degraded below acceptable limits.

Projected seasonal flow and dissolved oxygen conditions in the St. Francis River below Marked Tree are given in Table VI-3.

Table VI-2

Annual Low Flow Distribution (By Months)
in the St. Francis River at Marked Tree
(Without Siphon)

Month	Percent of Annual Flow	Total Discharge (Acre-Feet) At Various Exceedence Frequency Percentages		
		95%	90%	80%
January	8.2	16,000	19,000	24,000
February	13.3	27,000	31,000	39,000
March	15.5	31,000	36,000	45,000
April	13.8	28,000	32,000	40,000
May	12.0	24,000	28,000	35,000
June	9.5	19,000	22,000	28,000
July	7.6	15,000	18,000	22,000
August	5.3	11,000	12,000	15,000
September	3.7	7,000	9,000	11,000
October	2.7	5,000	6,000	8,000
November	3.2	6,000	8,000	9,000
December	5.2	10,000	12,000	15,000

Annual Flow

1. Exceeded 95% of time - 200,000 acre-feet.
2. Exceeded 90% of time - 235,000 acre-feet.
3. Exceeded 80% of time - 290,000 acre-feet.

Table VI-3

Projected Seasonal Flow and Dissolved Oxygen Conditions
in the St. Francis River Below Marked Tree

Season	Low Flow (mgd)	Low Flow (cfs)	D. O. Concentration at Critical Deficit (ppm)	Water Temperature (Degrees Centigrade)
Winter	109	169	10.2	8
Spring	252	390	7.3	22
Summer	112	173	6.7	28
Fall	57	88	7.8	18

VII. WATER RESOURCES

Ground Water

Ground water is the chief source of supply for all the principal municipalities in the study area as shown by Table VI-1. The most important water-bearing deposits in the study area are the "1,400-foot" sands of the Teritary age.[12/] Wells from these sands have an average yield of over 500 gpm. Much greater demands than presently exerted may be supplied from these sands before their maximum yield potential is exceeded.

Water from the sands is of very good quality. Concentrations of chemical constituents in ground water supplies are shown in Table VII-1.

Table VII-1

Typical Ground Water Quality [13/]
In the Study Area
(Concentrations in mg/l.)

Sampling Point	Trumann	Lepanto	Marked Tree	Earle	Parkin
Date	5/61	9/60	5/60	5/60	2/58
pH	7.8	7.7	8.0	7.5	7.3
Alkalinity	99	95	85	79	87
Hardness ($CaCO_3$)					
Carbonate	7.0	4.0	3.0	4.0	48
Non. Carb.	0	0	0	0	0
Calcium (Ca)	2.0	1.2	0.8	0.8	13.5
Magnesium (Mg)	0.4	0.2	0.2	0.4	3.5
Iron (Fe)	0.3	0.4	0.2	0.2	0.7
Manganese (Mn)	0.1	0	0	0	0
Chloride (Cl)	5.0	4.5	1.0	2.0	3.0
Sulfate (SO_4)	1.0	3.0	5.0	1.5	0
Total Solids	147	141	130	126	86

Surface Water

No reservoirs currently exist or are under construction in the study area. At present, only one reservoir exists on the St. Francis River system. The Wappapello Reservoir, constructed to control downstream flooding along the alluvial valley, is located in the upper reaches of the St. Francis River (above the Arkansas State line).

Though currently not used for municipal or industrial water supply, streamflow in the study area provides a valuable water supply source.

As indicated earlier, mean flows in the river at Marked Tree are many times greater than the amount of water currently being used throughout the three-county study area.

Surface water in the St. Francis River is also of very good chemical quality--within limits suggested by the Public Health Service Drinking Water Standards, 1961. [14] A summary of analyses of the water quality at Marked Tree is shown in Table VII-2.

Table VII-2 12/

Summary of Chemical Analyses
St. Francis River at Marked Tree, Arkansas
(Period of Record--Water Years 1946, 1950-1955)
(Concentrations in mg/l.)

	pH	Color	Fe	Hardness as $CaCO_3$		F	K	Mg	Ca	NO_3	HCO_3	Na	SO_4	Cl	Total Solids
				Carbonate	Non-Carbonate										
Maximum	8.4	25	0.3	329	262	0.3	3.0	20	76	3.6	328	13	28	10	329
Minimum	7.7	5	0.0	64	0	0.0	2.1	5.8	13	0.9	58	1.9	4	2	87
Arith. Avg.		12	0.1	172	10	0.1	2.5	13	47	1.7	169	7.9	16	6	224

VIII. PLANS FOR SUPPLYING FUTURE WATER REQUIREMENTS

Detailed plans for supplying water to the study area are beyond the scope of this study; however, there appears to be an abundance of good quality water in the area both from the highly productive (yield--over 500 gpm) "1,400-ft." sands and from the St. Francis River.

Current ground water supply systems are capable of yielding about 6 mgd (see Table VI-1). The additional 5 mgd expected to be needed in the year 2020 could be met by further development of the ground water source mentioned or use of water from the St. Francis River.

IX. PROJECT BENEFITS

The expected monthly distribution of low flows expected to recur once in 20 years at Marked Tree is more than adequate to assimilate treated future waste discharges to the stream below the siphon.

There is, therefore, no need for or benefit from regulation of streamflow for the purpose of water quality control.

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